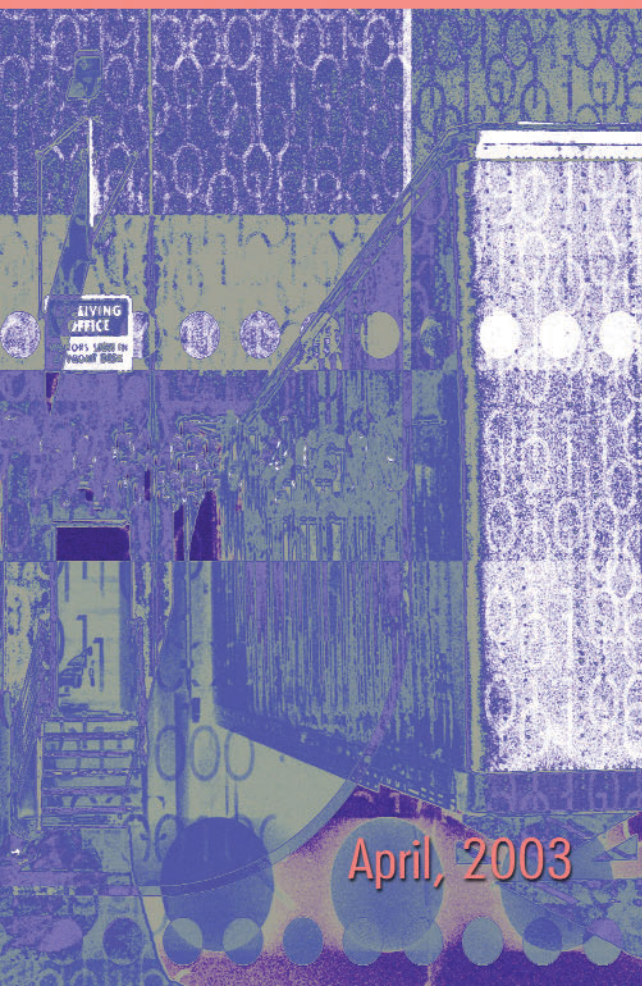# Year 2000 Model Validation & Summary
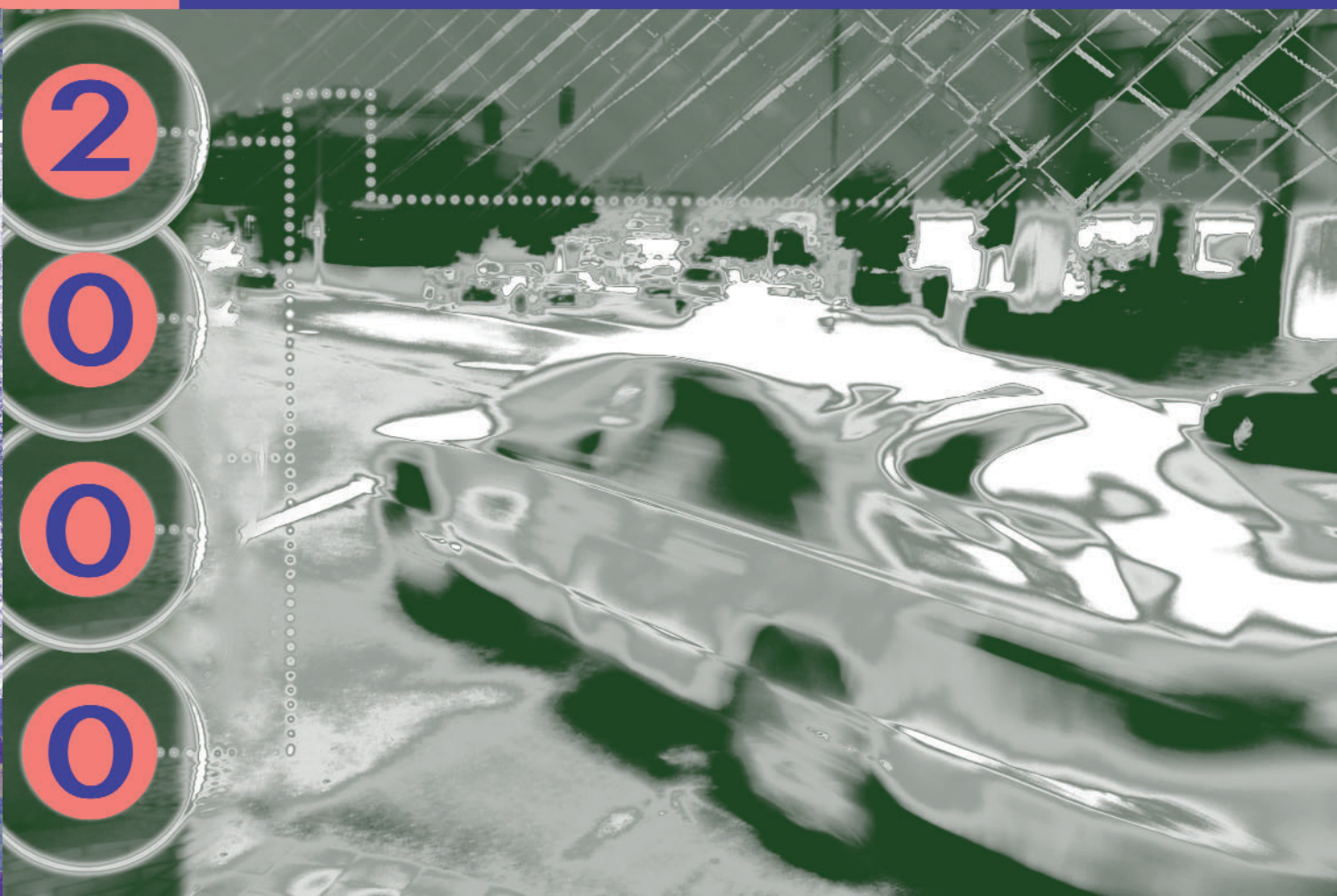## Regional Transportation Model

SOUTHERN CALIFORNIA **ASSOCIATION of GOVERNMENTS**

2000

April, 2003

Mission Statement

Leadership

Vision

Progress

Leadership, vision and *progress* which promote economic growth, personal well-being, and livable communities for all Southern Californians.

The Association will accomplish this Mission by:

- Developing long-range regional plans and strategies that provide for efficient movement of people, goods and information; enhance economic growth and international trade; and improve the environment and quality of life.

- Providing quality information services and analysis for the region.

- Using an inclusive decision-making process that resolves conflicts and encourages trust.

- Creating an educational and work environment that cultivates creativity, initiative, and opportunity.

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Preface

The Southern California Association of Governments (SCAG) is a voluntary association of six counties (Los Angeles, Orange, Ventura, Riverside, San Bernardino, and Imperial) and of 187 cities within those counties. SCAG's organizational purpose is cooperative planning and governmental coordination at the regional level. SCAG is also mandated by State and federal law to plan and implement a Regional Transportation Plan (RTP), which is to be updated every three years, and to identify Transportation Control Measures (TCMs) for incorporation into the Air Quality Management Plan (AQMP) for the South Coast Air Basin.

This report describes how SCAG forecasts travel behavior for the Southern California Region using computer-based software programs. The specific focus of this report is on the transportation modeling procedures that have been used to produce travel forecasts for the Year 2000. The Year 2000 model results have been compared and correlated to model estimates from previous SCAG forecasts and to other independent sources of travel data within the Region (traffic counts, transit ridership, travel survey data, etc.).

Year 2000 is the "base year" for the transportation planning period. This model base year is also being applied as part of the Regional Transportation Plan (RTP), the Air Quality Management Plan (AQMP) update, and in Congestion Management Programs (CMPs) prepared by individual counties within the Southern California Region.

The Regional Transportation Model provides a common foundation for transportation planning and decision making by SCAG and other agencies within the Region. The Year 2000 base year travel data contained in this report will be referenced by, and of interest to the general public, as well as local, State, and federal agencies involved in transportation planning and traffic engineering.

A number of State, subregional, and local agencies in the SCAG Region also perform travel demand model forecasting for their own transportation planning and engineering purposes. These modeling programs require a high degree of coordination and cooperation with SCAG's Regional modeling program. State agencies involved in travel forecasting include the California Department of Transportation (Caltrans) Districts 07, 08, 11, and 12. Subregional agencies include the Los Angeles County Metropolitan Transportation Authority (LAMTA), the Orange County Transportation Authority (OCTA), the Riverside County Transportation Commission (RCTC), San Bernardino Associated Governments (SANBAG), the Ventura County Transportation Commission (VCTC), the County of Orange Environmental Management Agency, and others. Local agencies including cities and counties within the Region also maintain transportation modeling programs. Several of these agencies have contributed directly to preparation of SCAG's Year 2000 Model Validation.

Questions about the content of this report, as well as requests for more detailed information, should be directed to Dr. Deng Bang Lee, SCAG's Manager of Regional Transportation Modeling/GIS, at (213) 236-1855 or via e-mail at lee@scag.ca.gov

Chapter 1
Overview

Overview

Introduction

This report documents the results of the Year 2000 Model Validation process for SCAG's Regional Transportation Model. Model validation is defined as the process by which base year model results are compared to "known" sources of data such as traffic counts and transit ridership data. SCAG performs a validation of its transportation model at the beginning of every planning cycle for the Southern California Region. A planning cycle is typically three years, corresponding to the update of the Regional Transportation Plan. The "base year" for the current planning period is Year 2000, and Year 2030 is the "forecast year". Model validation is a regular and essential modeling process that supports development of the Regional Transportation Plan (RTP), the Regional Transportation Improvement Program (RTIP), and the Air Quality Management Plan (AQMP).

In the past, SCAG has prepared a model validation report for each of the previous planning cycle base years: 1980, 1984, 1987, 1990, 1994, and 1997. The base year of 2000 now replaces the previous base year of 1997. The Year 2000 Origin and Destination Survey database was used to update the peaking factor, and mode choice models. Regional Model input assumptions and parameters such as socioeconomic data and travel behavior data, established during the Year 2000 validation effort, as well as specific model adjustments made during that effort, will be applied during the analysis and evaluation of the Regional Transportation Plan (RTP).

The general objective of the Year 2000 Model Validation effort was to analyze the performance of the Regional Transportation Model compared to independent sources of travel data, such as traffic counts (ground counts taken along regional highways within the Region), transit ridership data, and vehicle miles traveled estimates.

Technical Approach

The Year 2000 Model Validation process ensures that the Regional Transportation Model accurately predicts traffic volumes and transit usage in the Year 2000. The enhancements to the transportation modeling process (see inset) are described in greater detail in Chapters 2 through 8 of this report. Reports documenting the development and calibration of the trip generation, trip distribution, and mode choice models, as well as the Heavy-Duty Truck Model are referenced in the List of Bibliographies at the end of this report. Finally, refinements in the methods used to determine auto operating cost and vehicle-control-totals were estimated by using a snapshot of Department of Motor Vehicles (DMV) data provided to SCAG by the California Energy Commission (CEC).

To assure a successful model validation, two key practices were followed:

- The most recent socioeconomic input data (including residential population, group quarters population, occupied housing units, workers, median household income, and employment by type) was used in the Year 2000 Validation.

  It is critical to the success of the Regional Transportation Model to use data from the most reliable source. Socioeconomic data is the first input in the transportation modeling process. Because the modeling process is sequential, each step builds upon the last, so errors in the socioe-

Major Model Improvements:

- An expanded modeling study area and a more fine-grained zonal system (Figure 1-1)

- Updated household trip generation and trip attraction models

- An enhanced highway network developed from a GIS base, with more sophistication in freeway and arterial link representation

- An expanded and enhanced mode choice model

- An enhanced convergence (feedback looping) process to better reflect congested speeds (Figure 1-2)

- A new parking cost model

- Incorporated Transit Vehicles in highway assignment

- New peaking factors from 2001 Travel Survey

Figure 1-1

SCAG Modeling
Study Area

Legend
1994 Modeling Area
2000 Modeling Area

Ports
Major Airports
Ports of Entry
Freeway
Highway
County
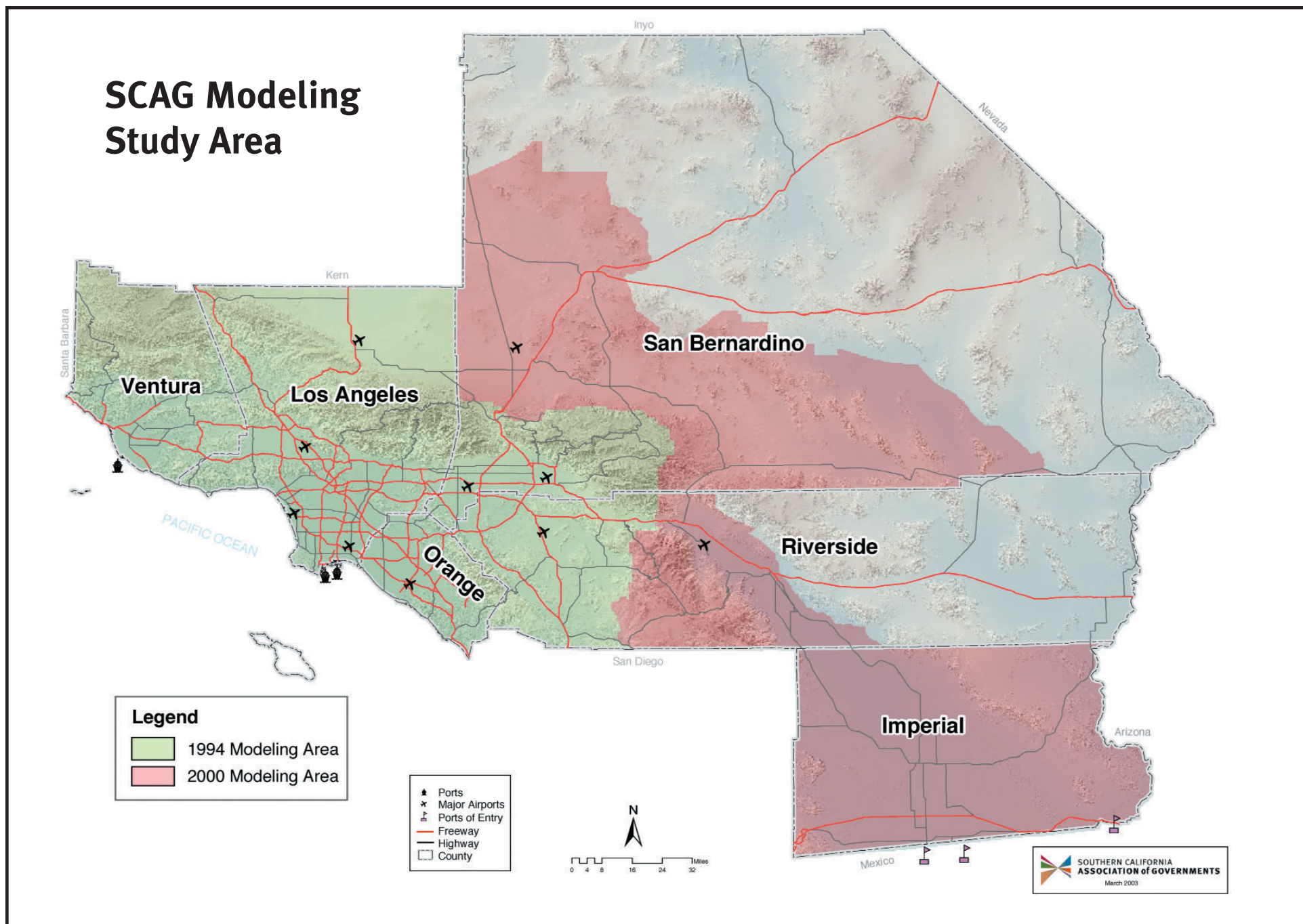
Figure 1-2a

SCAG Regional Travel Demand Modeling Process
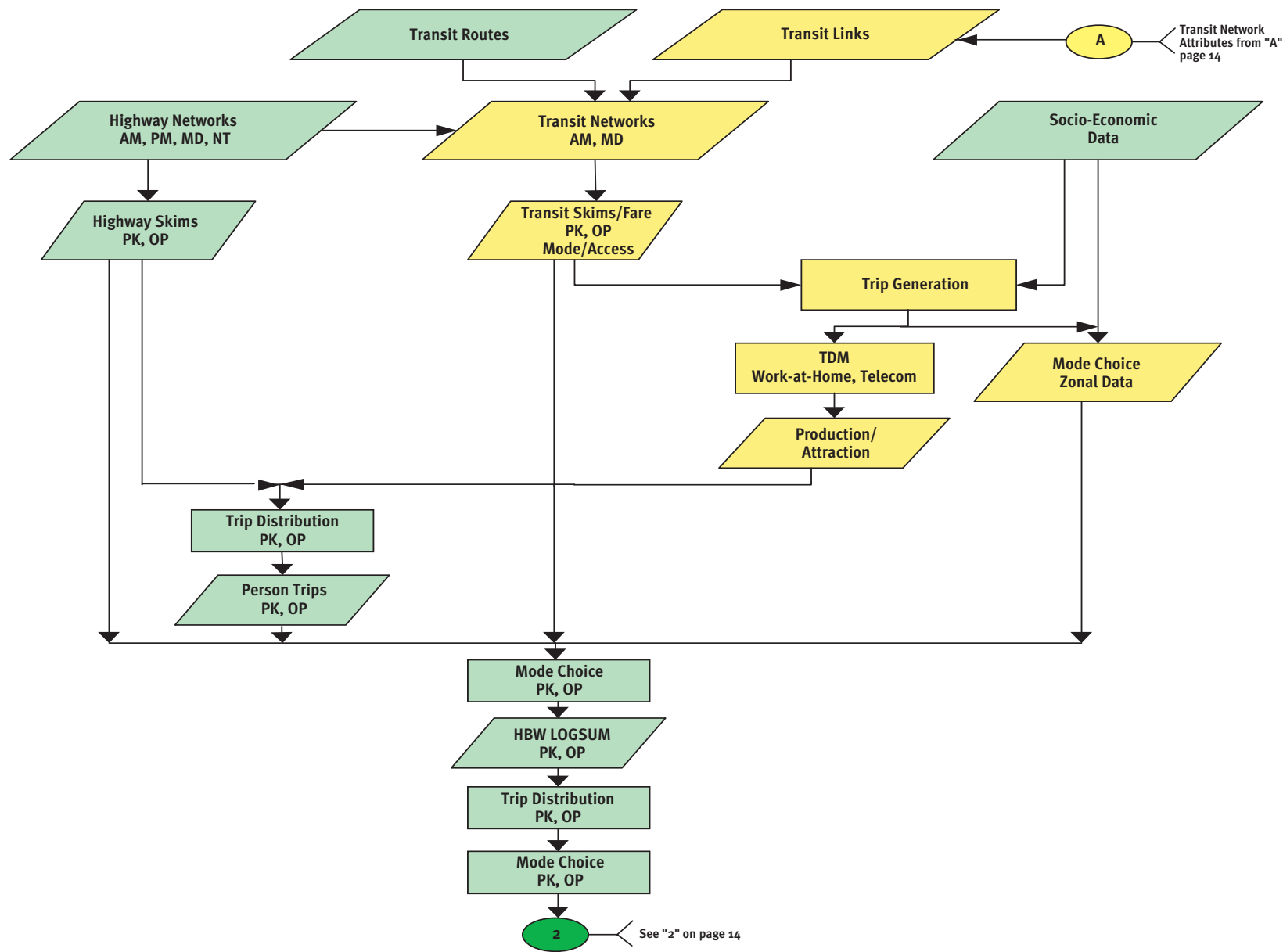
Figure 1-2b

SCAG Regional Travel Demand Modeling Process
Heavy-Duty Truck Trip Generation and Distribution

SED/
1 Digit SIC

Internal Truck
Trip Generation

Trip Rate

Internal HDT Trip
Distribution

SED/
2 Digit SIC

External HDT Trip
Distribution

Annual
County Cordon
Trip Table

Ports and
Airport HDT Trips

HDT Trip Tables
AM,PM, MD, NT

WIM Station
Surveys

B

See "B" on page 14
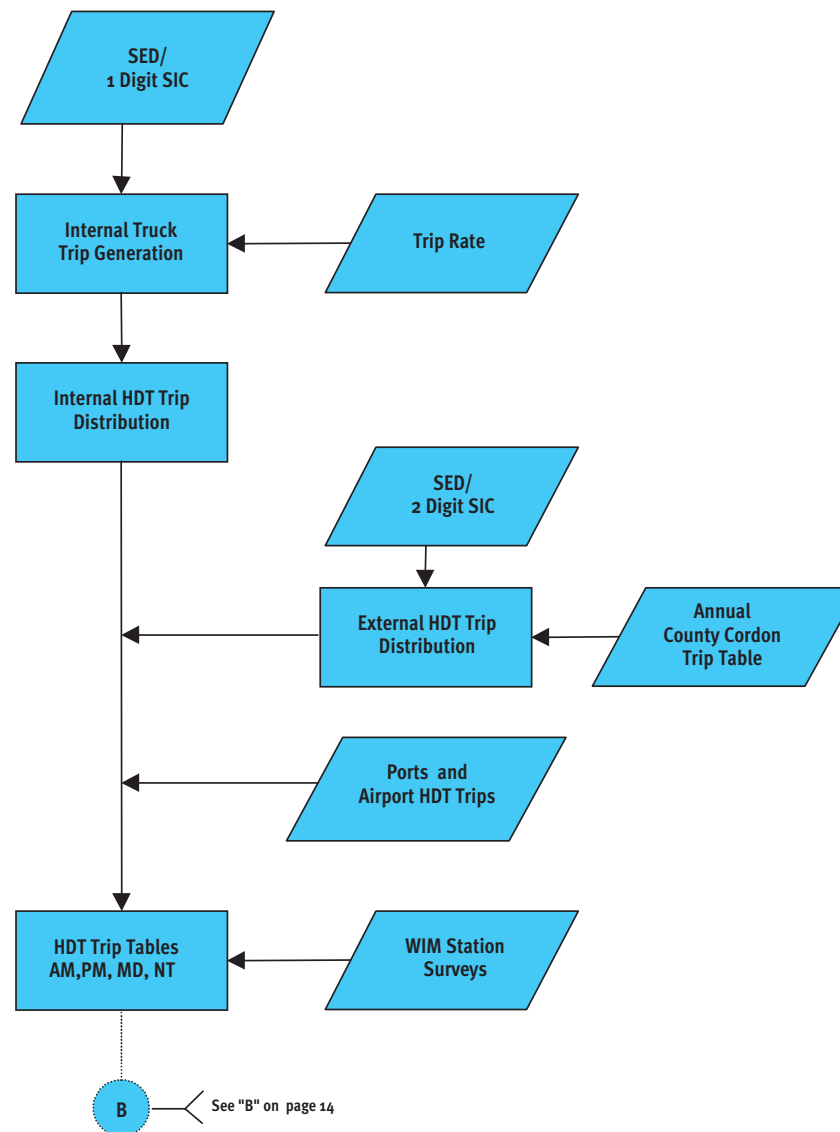
Figure 1-2c

SCAG Regional Travel Demand Modeling Process
Trip Assignment and Convegence
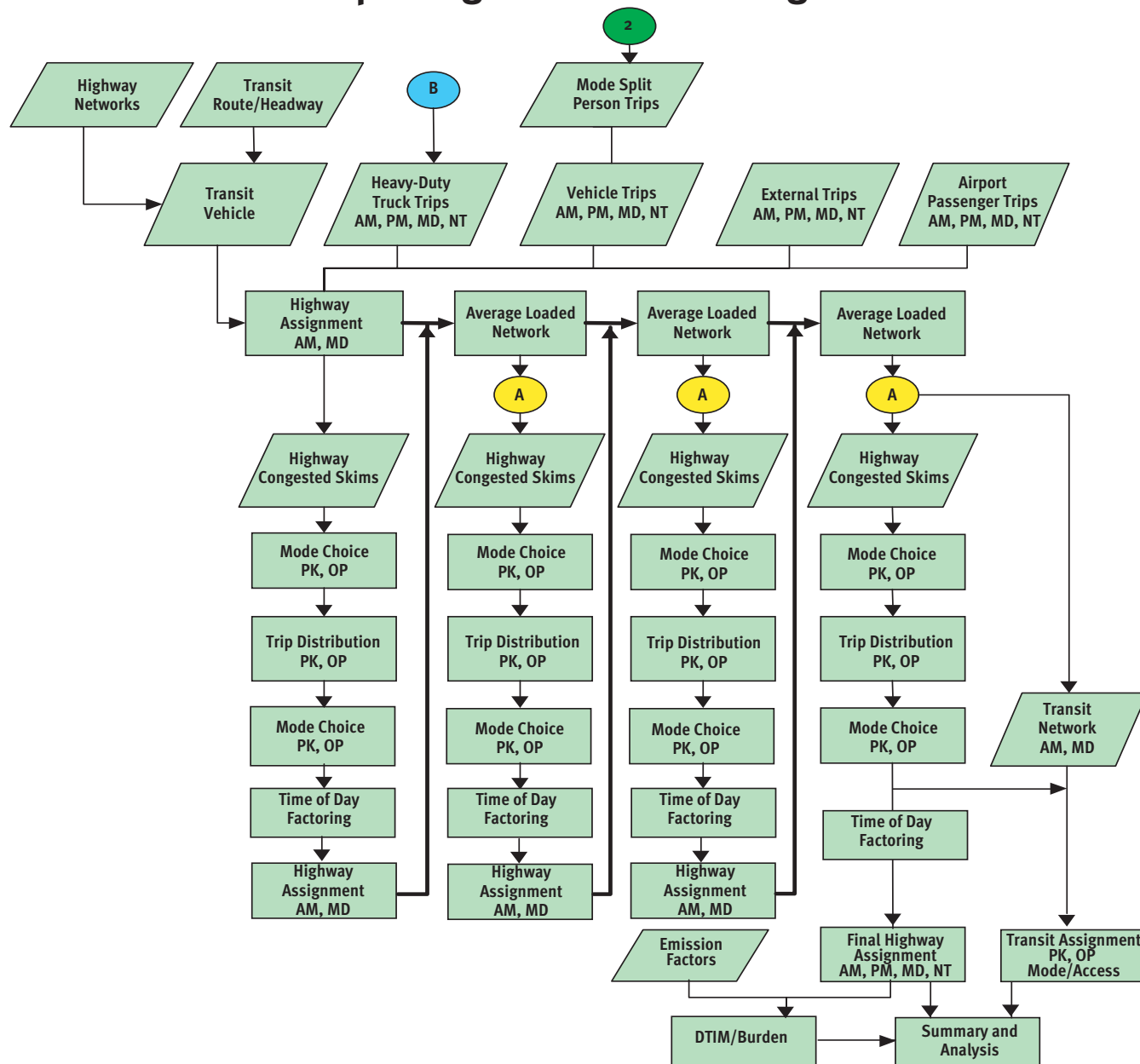
conomic data cause cumulative errors in the modeling process. Year 2000 U.S. Census data was used as a primary source for many of the socioeconomic variables, such as residential population, group quarters population, occupied housing units (including single family dwelling units and multiple family dwelling units), number of workers, and median household income. Two key sources of employment data included the American Business Information (ABI) files and the Dun & Bradstreet (D & B) files. The ABI and D & B files are considered to be the most reliable employer databases available.

■ Several measures were applied during the development of the Year 2000 Model to insure that the validation tests would be objective.

It was critical that the validation tests provide objective comparisons to model results from past base year models. One measure was to apply the same procedures to develop key Year 2000 model input parameters (such as auto operating, transit fare, and zonal parking costs), as had been used when the models were originally calibrated (or adjusted to reflect known data).

Another measure applied by staff was to use the same (or reasonably consistent) street, highway, and transit network coding conventions for the Year 2000 model networks (especially the transit network) as had been used previously. The Model is particularly sensitive to assumptions used in developing transit walk access and auto access times. Consistency between these assumptions

was necessary for an unbiased and objective comparison of model results with those of prior year models.

The last measure applied by staff was to use modeling techniques and coding conventions that follow standard and accepted professional modeling practice.

Modeling Area

The Regional Model's study area includes Los Angeles County, Orange County, Ventura Counties, and the urbanized sections of Riverside County and San Bernardino County. The Regional modeling area was recently expanded to also include the Victor Valley and Barstow areas, the Morongo Valley, the Coachella Valley, and the Idyllwild area. Imperial County has been included on each map/ figure for reference purposes. A separate model is maintained for Imperial County which better captures the unique travel behavior of this rural agricultural area. Figure 1-1 depicts the regional modeling area.

Zone System

The Transportation Analysis Zones (TAZs) provide the spatial unit (or geographical area) within which travel behavior and traffic generation are estimated. Figure 1-3 provides a map of the TAZ system. The zone system includes 3,191 TAZs. Appendix B provides a detailed description of the methodology used to create the zone system and presents a table summarizing the zones by county.

The Regional Transportation Model uses twenty-six external stations (cordons) to account for external trip making. An external trip is a trip with at least one of its trip ends

falling outside the modeling area. This includes the following types of trips: trips starting inside the modeling area to outside the area, trips from outside the area to inside the modeling area, and through trips which travel from one cordon to another cordon. Figure 1-4 depicts the 26 cordon stations, or points of entry and exit along streets and highways at the perimeter of the expanded modeling area.

Overview of the Report

Performance of the Year 2000 Model, and key comparative statistics, are summarized in this section by major modeling component: trip generation, trip distribution, mode split, and trip assignment. Details of the various models, as well as the model inputs are described in the following Chapters.

Chapter 1	Overview
Chapter 2	Socioeconomic Data
Chapter 3	Trip Generation
Chapter 4	Transportation Networks
Chapter 5	Trip Distribution
Chapter 6	Mode Choice
Chapter 7	Heavy-Duty Truck Model
Chapter 8	Trip Assignment
Chapter 9	Air Quality Impact Analysis

Additional technical details are included in Appendices A through G.

Appendix A	Socioeconomic Variable Definitions
Appendix B	The Regional Transportation Analysis Zone (TAZ) System
Appendix C	Regional Highway Network Coding Conventions
Appendix D	Specification of Trip Production Models
Appendix E	Specification of Trip Attraction Models
Appendix F	Specification of Mode Choice Models
Appendix G	Auto Operating Costs

Overview of the Model Validation Findings

Trip Generation

The first step in the modeling process is to generate person trips by TAZ. Person trips are generated for each of the 13 trip types based on the socioeconomic data described in Chapter 2. Results of this process include trip productions (primarily from residential land uses) and attractions (primarily related to employment) for each trip type. Details regarding the specific steps used to generate person trips are provided in Chapter 3.

The Regional Modeling Area

The following counties are included in the Reginal Mdeling Area:

- Los Angeles County
- Oange County
- Ventura County
- Riverside County (Excluding the sparsely populated eastern desert)
- San Bernardino County (Excluding the sparsely populated eastern desert)
- Imerial County (Imperial County is within the Regional Modeling Area, however the model used to forecast travel is described in a separate report)

Figure 1-3

The Traffic Analysis Zone System

Number of Zones

Los Angeles	1,721
Orange	550
San Bernardino	374
Riverside	347
Ventura	199
Imperial	636
TOTAL	3,827

Ventura

Los Angeles

San Bernardino

Orange

Riverside

Imperial

LEGEND

2000 TAZ Boundary

SCAG County Boundary

N

10 0 10 20 30 Miles

SOUTHERN CALIFORNIA
ASSOCIATION of GOVERNMENTS
March 2003

Source: SCAG Modeling Section, Thomas Bros.
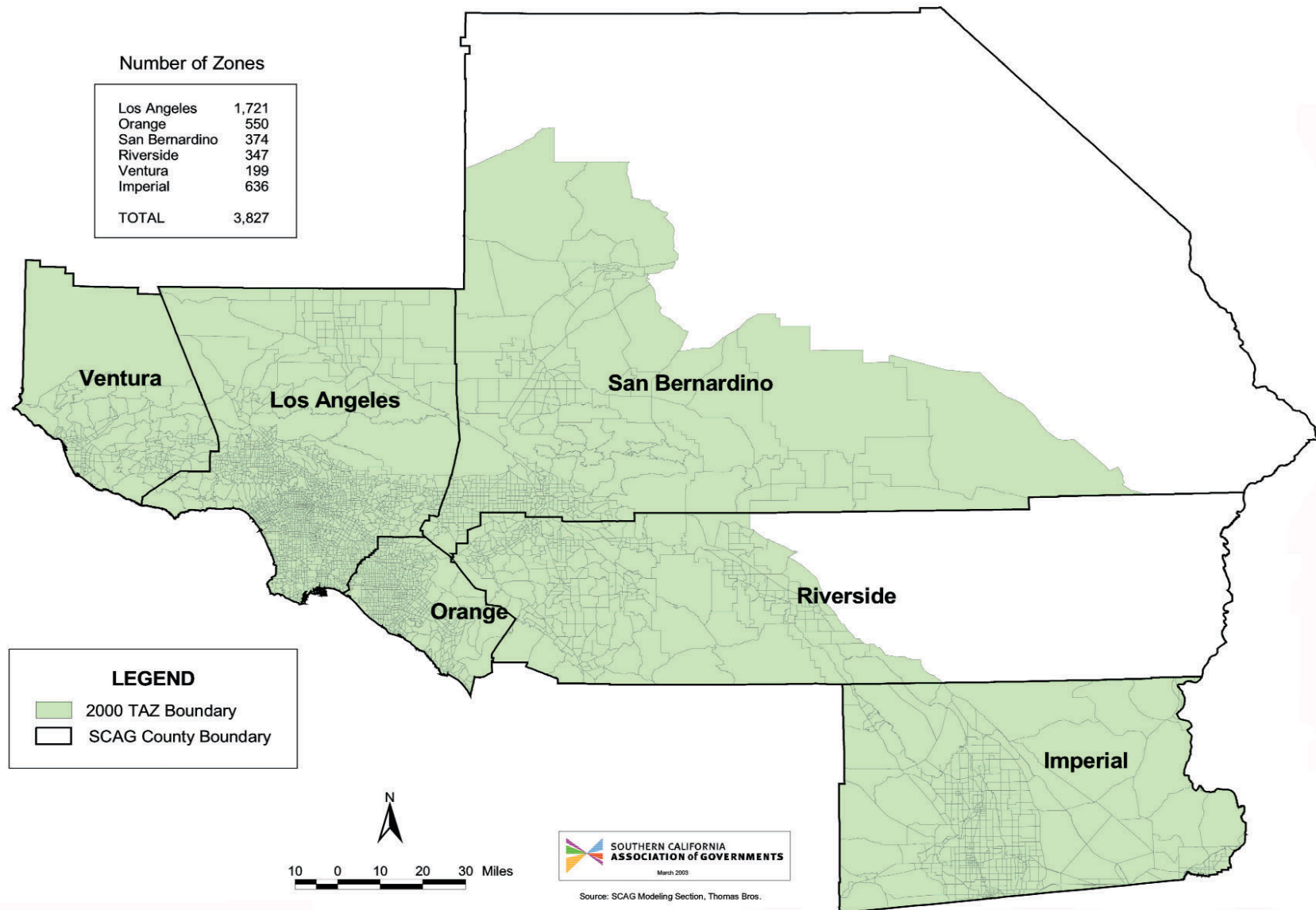
Figure 1-4

Modeling Study Area Cordon Locations

Cordons

1. US 101/SB Co. Line
2. Rt 150 Santa Ana Cyn Rd
3. Rt 33/SB Co. Line
4. Lockwood Valley Rd/KN Co.
5. I-5/Kern Co. Line
6. 100th St/Kern Co. Line
7. 90th St/Kern Co. Line
8. 60th St/Kern Co. Line
9. Rt 14/Kern Co. Line
10. Sierra hwy/Kern Co. Line
11. 140th St/Kern Co. Line
12. US395 W. of Rt58
13. Rt 58/Kern Co. Line
14. Fort Irwin Rd/Paradise Sp.
15. SB I-15/Paradise Spings Rd
16. SB I-40/A St
17. Rt 62/Riverside Co. Line
18. RV I-10/Polk St
19. Box Canyon Rd/Coachella
20. Rt 111/Imperial Co. Line
21. Rt 86/Imperial Co. Line
22. Rt 79/SD Co. Line
23. S16/SD Co. Line
24. I-15/SD Co. Line
25. De Luz Rd/SD Co. Line
26. I-5/SD Co. Line

LEGEND
- Cordons
- 2000 Modeling Study Area
- SCAG County Boundary

Source: SCAG Modeling Section, Thomas Bros.

Results of the trip generation model indicate that 55,556,231 person trips were generated on a typical Year 2000 weekday within the Regional modeling area depicted in Figure 1-1. It should be noted that the modeling area was expanded to include the urbanizing areas within the Region's mountain and desert areas. Table 3-2 provides summary statistics for trip generation. Table 3-2 also indicates that 9,051,947 or 16.3 percent of total daily trips in Year 2000, were home-based work trips

Trip Distribution

Details regarding how trips were distributed are provided in Chapter 5. Before the trips can be distributed between zones, highway and transit networks must be developed. Chapter 4 provides a thorough explanation of the network coding process. The results of the trip distribution model indicate that about 92.5 percent of the Year 2000 home-work trips generated in Los Angeles County had destinations within the County. Orange County retained approximately 79.7 percent of its Year 2000 estimated home-work trips. Ventura County retained about 76.6 percent of its home-work trips. San Bernardino County's estimated intra-county work trip percentage was 64.9 percent, while Riverside County's intra-county home-work trip percentage was 68.3.

Mode Choice

Chapter 6 provides details regarding the mode choice model. The procedures applied to estimate mode split produced 512,195 daily home-work transit trips in the expanded modeling area for Year 2000. The remaining (non-transit) home-work person trips were estimated at 8,823,422 vehicle trips. These trips were grouped considering vehicle occupancy, resulting in: 8,194,524 drive alone vehicle trips, 453,895 two-person vehicle trips, and 175,003 vehicle trips with three or more persons. Total weekday transit ridership in Year 2000 was estimated at 1,185,606. Total daily vehicle trips in Year 2000 resulted in an average vehicle occupancy of 1.43. The daily home-to-work average vehicle occupancy is 1.10.

Trip Assignment

Details regarding trip assignment for each mode are provided in Chapters 7 and 8.

Once the highway trips were assigned to the network, the estimates were validated by comparing Average Weekday Traffic (AWT) volumes predicted by the Model, to "observed" traffic counts along the sixteen regional screenlines. Screenlines are defined as imaginary lines that cross one or more freeways and/or major streets that are parallel to one another. Overall, the total model-predicted screenline volumes (across all screenlines) differed by less than 3.5 percent from the total observed daily counts along the same screenlines. The Heavy-Duty Truck Model volumes across all screenlines were about 12 percent higher than observed truck counts. These screenline results were found to be within the tolerance level consid-

ered acceptable for a regional transportation model. Results of the trip assignment process indicated there were 340,330,000 Vehicle Miles Traveled (VMT) on an average weekday in Year 2000 by light and medium duty vehicles (passenger cars, pick-ups, single unit trucks, and recreational vehicles). In addition, the Heavy-Duty Truck Model estimated 22,431,000 daily vehicle miles of travel by heavy-duty trucks within the Region. The heavy-duty truck volumes represent about 6.6 percent of the total regional vehicle mile traveled. Light and Medium Duty VMT results within the South Coast Air Basin are 2 percent below corresponding benchmark VMT statistics derived from the Highway Performance Monitoring System (HPMS) data for all vehicles. Light and Medium Duty VMT results for the Ventura County portion of the modeling area are within 4.6 percent of the corresponding HPMS data.
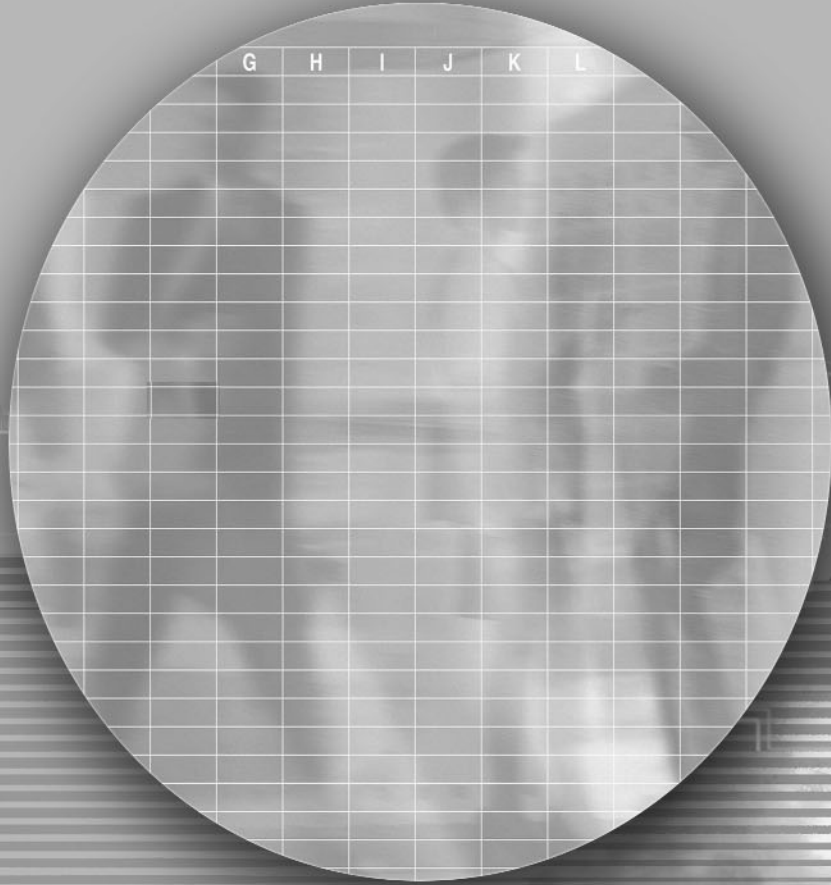
Chapter 2

Socioeconomic
Imput Data

Socioeconomic Input Data

Introduction

This Chapter identifies and defines the socioeconomic variables used to generate person trips in the Regional Transportation Model. The source of each socioeconomic variable (population, workers, households by type, household income, school enrollment, household size, and employment by type) is identified, and the methodology used to allocate the data into individual Traffic Analysis Zones (TAZs) is described. Summary statistics for each major variable by county in the modeling area are also provided.

Socioeconomic Input Variables

SCAG's trip generation model uses the following socioeconomic variables.

● **Population: Total Population, Resident Population, and Group Quartered Population**

■ **Total Population** is the total number of people living within a zone, including all population types documented in the U.S. Census.

■ **Resident Population** is the number of residents NOT living in "group quarters".

■ **Group Quartered Population** is primarily comprised of students residing in dormitories, military personnel living in barracks, and individuals staying in homeless shelters. Group Quartered Population does NOT include persons residing in institutions. The current generation model uses only Resident Population to generate trips.

● **Workers**

The "Workers" or employees variable is the total number of employed persons residing in a zone, as distinguished from the employment variables, which represent the number of "employees" working at a location in a zone. Workers are tallied by place of residence versus place of employment. The Workers variable includes both the full and part time labor force residing in households (see definition of household below). Therefore, no group quartered workers are counted (i.e. military personnel in barracks and students in dorms are not counted).

● **Households: Single Households and Multiple Households**

Household data was developed for both Single-Family and Multiple-Family Households. Each are described below:

■ **Single Family Households** contains the number of households in permanent and occupied single-family homes with detached roofs (also known as "single-family detached" housing).

■ **Multiple Family Households** contains the number of all other households not considered Single-Family households, including occupied housing with "attached" roofs, condominiums, duplexes, triplexes, apartments, mobile homes, and other types of non single-family dwellings such as houseboats, recreational vehicles, tents, and others.

Socioeconomic Inputs:

- **Total Population**
- **Resident Population**
- **Group Quartered Population**
- **Workers**
- **Single Family Households**
- **Multiple Family Households**
- **Median Household Income**
- **K-12 School Enrollment**
- **College/University Enrollment**
- **Household Size**
- **Retail Employment**
- **Service Employment**
- **...Basic Employment**

● **Household Income:
Median Household Income**

Median Household Income is the median value of household income for all households within a zone. Household Income includes the income, from all sources, for all persons aged 15 years or older within a household. For reasons related to the evolution of the Regional Model, the median household income level was adjusted to "1989 dollars", and applied as the "Median Household Income" input variable in the Year 2000 Model Validation.

● **School Enrollment: K-12 School and College/University Enrollment**

School Enrollment was reflected for both K-12 (kindergarten through 12th grade) and for colleges and universities. Each of the school enrollment variables are described below.

■ **K-12 School Enrollment** is the total number of K-12 (kindergarten through 12th grade) students enrolled in all public and private schools located within a TAZ. As a result, all elementary, middle (junior high), and high school students are included. This variable represents "students by place of attendance" versus "students by place of residence."

■ **College/University Enrollment** is the total number of students enrolled in any public or private post-secondary school (college or university), that grant a bachelors degree or higher, located within a zone. This variable represents "students by place of attendance" versus "students by place of residence."

● **Household Size**

■ Household Size represents the resident population (as defined above) in a zone, divided by total households in the same zone. Total households are equal to the sum of single-family households plus multiple-family households in a zone.

● **Employment: Retail, Service, and Basic Employment**

The employment variables represent all jobs whose place of employment is located within a TAZ (i.e., total jobs by place of work). Employment variable definitions are based upon Standard Industrial Classification (SIC) code definitions reflected in the 1987 version of the SIC. (Reference Appendix A for a listing of SIC codes).

■ **Retail Employment** includes all employees in SIC codes 52 through 59.

■ **Service Employment** includes all employees in SIC codes 70 through 89.

■ **Basic Employment** is defined as "all other employment, not Retail or Service". Therefore, Basic Employment consists of employees in all other SIC codes except for those in the Retail and Service sectors. The sum of Retail, Service, and Basic Employment equals total employment.

Input Data Summary

The results presented in the following tables and figures summarize the socioeconomic data inputs to the Year 2000 Model Validation process. Table 2-1 presents a summary of socioeconomic data totals by county and for the Southern California Region within the model area.

Figure 2-1 displays the population density by TAZ.

Figure 2-2 shows the employment density by TAZ.

Figure 2-3 shows the income distribution by TAZ.

Table 2-1

YEAR 2000 SCAG MODEL SOCIOECONOMIC INPUT DATA

POPULATION AND WORKERS				
COUNTY	RESIDENT POPULATION	GROUP QUARTERED POPULATION**	TOTAL POPULATION	RESIDENT WORKERS
Los Angeles	9,400,370	97,870	9,576,497	4,078,807
Orange	2,821,681	26,004	2,864,196	1,381,714
Riverside*	1,500,724	11,836	1,525,325	614,725
San Bernardino*	1,653,172	16,947	1,696,904	675,488
Ventura	744,798	8,601	758,096	359,207
TOTAL	16,120,745	161,258	16,421,018	7,109,941

SCHOOL ENROLLMENT		
COUNTY	K THRU 12 ENROLLMENT	COLLEGE AND UNIVERSITY ENROLLMENT
Los Angeles	2,060,618	730,310
Orange	571,973	230,750
Riverside*	355,958	86,097
San Bernardino*	419,874	108,261
Ventura	163,433	48,445
TOTAL	3,571,856	1,203,863

HOUSEHOLDS				
COUNTY	SINGLE HOUSEHOLDS	MULTIPLE HOUSEHOLDS	TOTAL HOUSEHOLDS	HOUSEHOLD SIZE
Los Angeles	1,545,449	1,590,398	3,135,847	3.00
Orange	481,207	457,162	938,369	3.01
Riverside*	325,677	177,787	503,464	2.98
San Bernardino*	363,744	158,338	522,082	3.17
Ventura	157,309	87,170	244,479	3.05
TOTAL	2,873,386	2,470,855	5,344,241	3.02

EMPLOYMENT				
COUNTY	RETAIL EMPLOYMENT	SERVICE EMPLOYMENT	OTHER EMPLOYMENT	TOTAL EMPLOYMENT
Los Angeles	705,500	1,729,059	2,035,699	4,470,258
Orange	264,776	546,947	702,826	1,514,549
Riverside*	100,880	168,053	234,516	503,449
San Bernardino*	122,224	189,026	280,072	591,322
Ventura	57,054	111,186	169,004	337,244
TOTAL	1,250,434	2,744,271	3,422,117	7,416,822

Note:
*County totals are for the part of the County in the SCAG modeling area only.

Figure 2-1

Year 2000 population Density

Persons per Acre
- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 60
- Over 60

PACIFIC OCEAN

N

8 0 8 16 24 Miles

SOUTHERN CALIFORNIA
ASSOCIATION of GOVERNMENTS
March 2003

Source: SCAG TAZ data, 2000
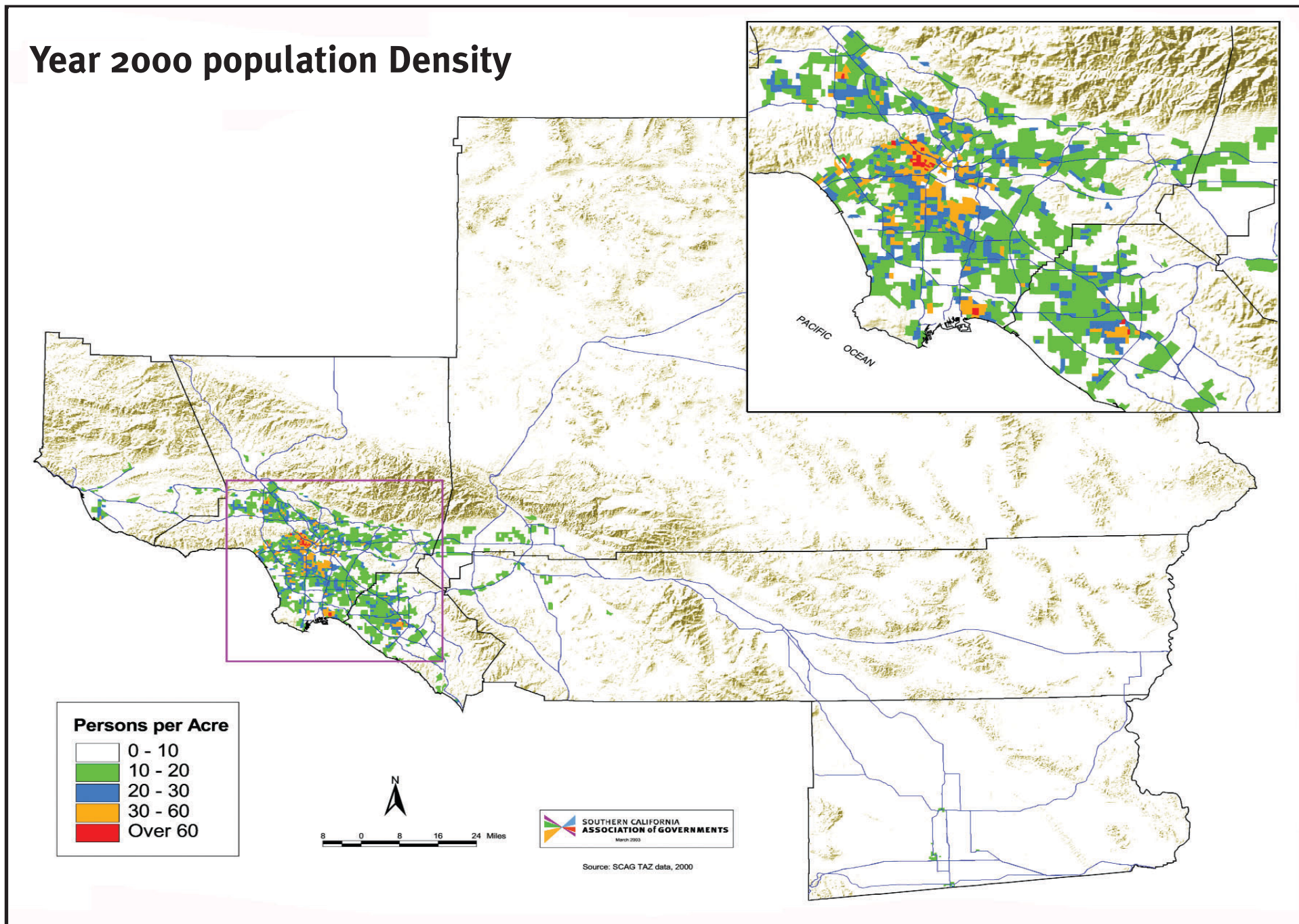
Figure 2-2

Year 2000 Employment Density

Employees per Acre
- Less than 5
- 5-20
- 20-50
- 50 - 100
- Over 100

PACIFIC OCEAN

N

8 0 8 16 24 Miles

SOUTHERN CALIFORNIA
ASSOCIATION of GOVERNMENTS
March 2003

Source: SCAG TAZ data, 2000
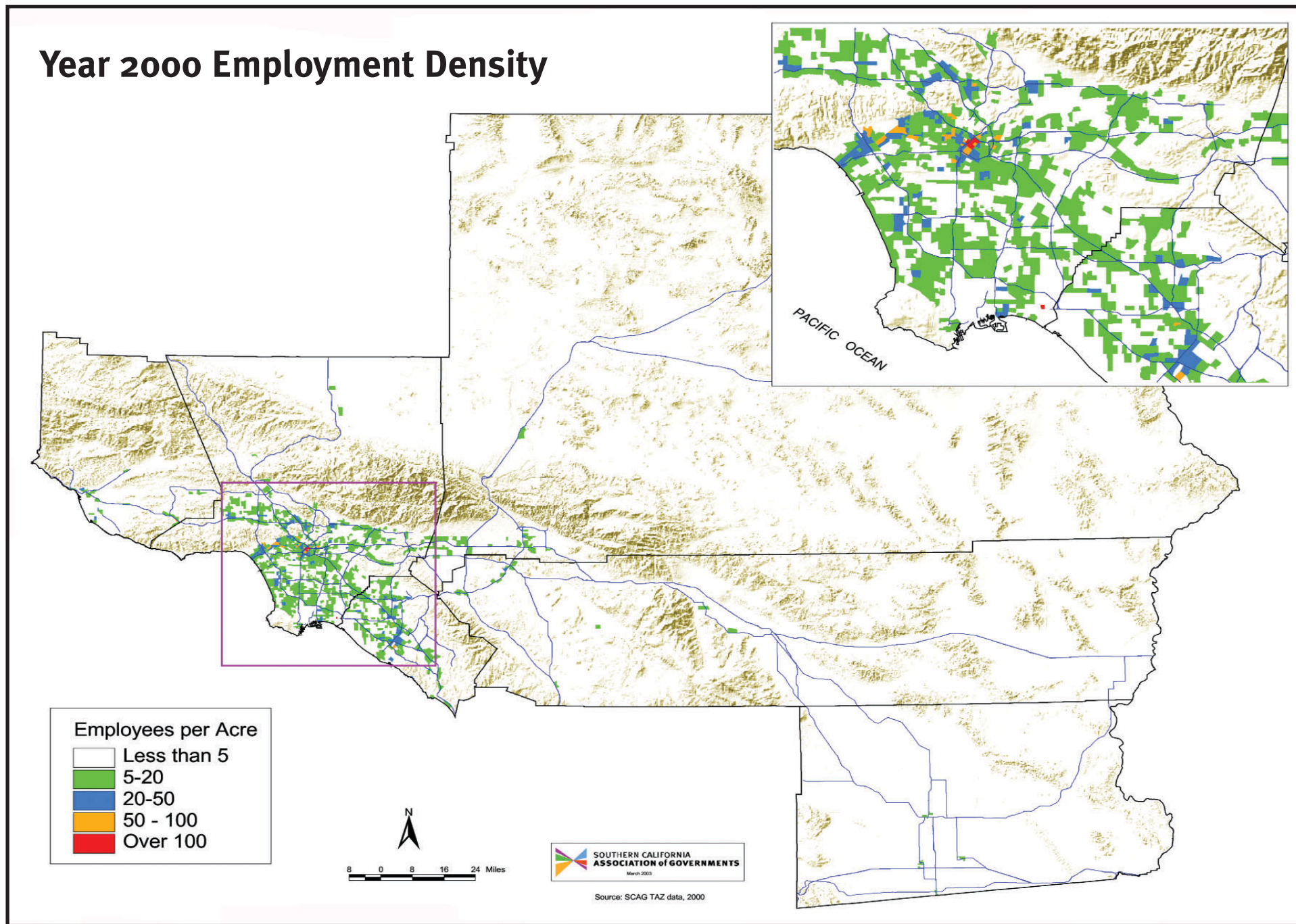
Figure 2-3

Median Household Income in 1989 Dollar

Income Distribution
- ☐ 0 - $20,000
- ☐ $20,000 - $50,000
- ☐ $50,000 - $75,000
- ■ Over $75,000

N

8   0   8   16   24   Miles

SOUTHERN CALIFORNIA
ASSOCIATION of GOVERNMENTS
March 2003

Source: SCAG TAZ data, 2000

PACIFIC OCEAN
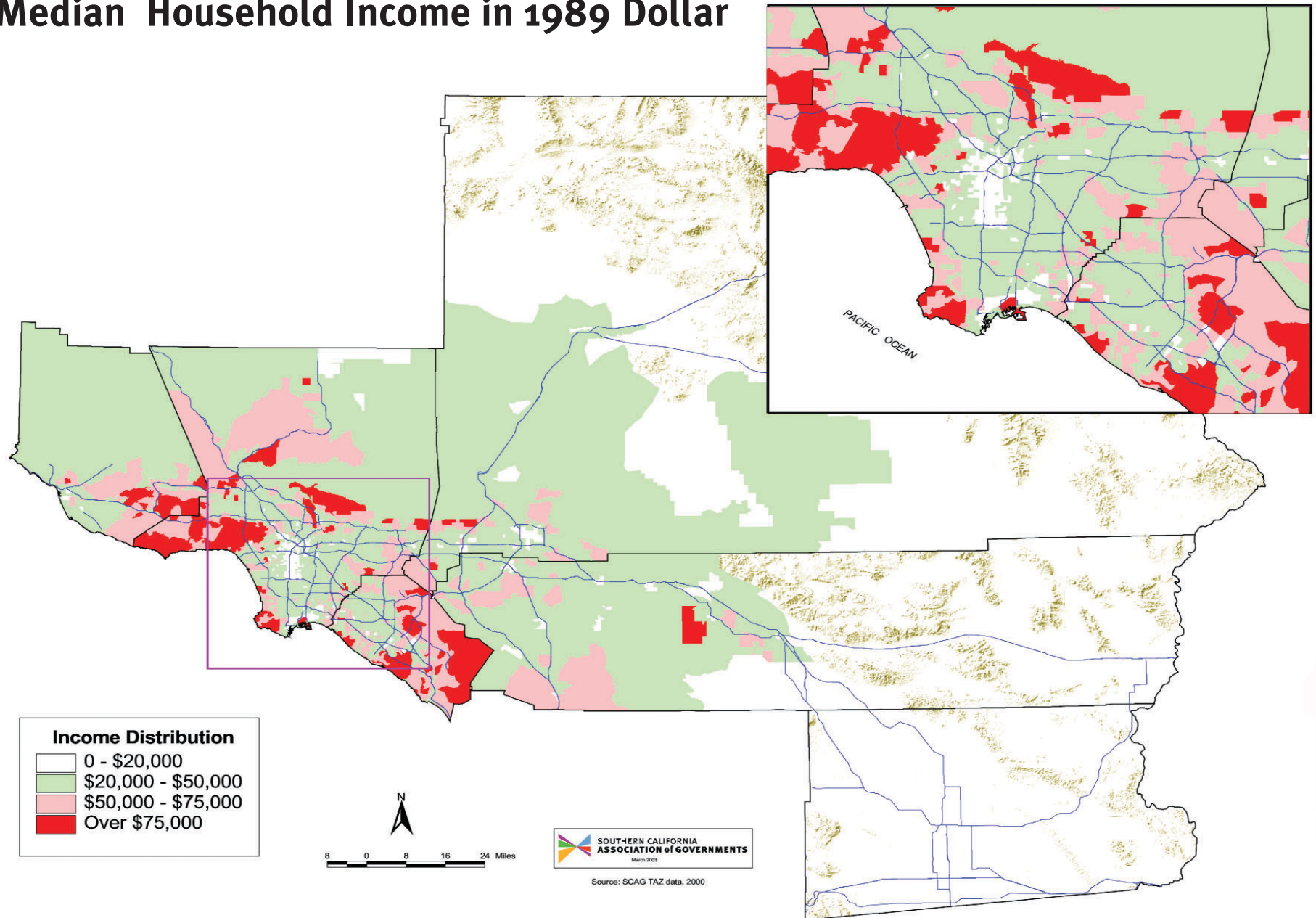
Chapter 3
Trip Generation

Trip Generation

Introduction

Trip generation is the process of estimating how many daily person trips are generated by households within each Traffic Analysis Zone (TAZ). A set of trip generation models was applied to estimate the number of person-trips generated in each zone for an average weekday. The trip generation models are referred to as "cross-classification" models that apply trip rates, by trip type to the number of households in each TAZ corresponding to each "stratified household category" (single and multiple-family households and group quarters). This Chapter describes the generation models applied for each of the 13 trip types. Further, the variables used to stratify the total number of households for each cross-classification model are identified. Finally, the socioeconomic submodels used to identify the households in each zone are described.

The results of the Year 2000 trip generation process are reported in this Chapter. The results are also compared to similar statistics from the 1997 model validation process. Comparisons are provided by percent of total trip making, by trip type, by the percentage of trips by type, and by county.

Description of the Trip Generation Model

The Year 2000 Model uses an expanded set of trip types. This was done to improve trip distribution and mode choice estimations, and to more accurately link trip productions and trip attractions for key trip types. Total trips produced by TAZ were estimated for each of the following 13 trip types:

Trip Types

- **"Direct" home-based work trips, Low Income**
- **"Direct" home-based work trips, Medium Income**
- **"Direct" home-based work trips, High Income**

"Direct" home-based work trips are trips that go directly between home and work, without any intermediate stops. The trip generation model estimates these types of trips separately for each of three different household income categories (expressed in 1989 equivalent dollars):

- **Low Income –** less than $19,999,
- **Medium Income –** $20,000 to $49,999,
- and **High Income –** $50,000 or greater.

The number of households in each income strata by zone is estimated by a cross-classification submodel described later in this Chapter.

- **"Strategic" home-based work trips, Low Income**
- **"Strategic" home-based work trips, Medium Income**
- **"Strategic" home-based work trips, High Income**

"Strategic" home-based work trips are trips between home and work that include an intermediate stop, such as to drop off or pick up a passenger, to drop off or pick up a child at school, or for other reasons. The trip generation model estimates strategic home-based work trips

separately for each of three household income categories. A cross-classification submodel estimates the number of households in each income strata described above.

■ Home-based elementary and high school trips

Home-based elementary and high school trips (K-12th) include all trips with an at-home activity at one end of the trip and a school activity at the other end. This purpose does not include trips in the college/university category, which follows.

■ Home-based college and university trips

Home-based college and university trips include all trips made by persons over the age of 18 with an at-home activity at one end of a trip and a college or university activity at the other end.

■ Home-based shopping trips

Home-based shopping trips include all trips made with a home activity at one end of a trip and and a shopping activity at the other end.

■ Home based social-recreational trips

Home-based social-recreational trips include all non-shopping trips made with a home activity at one end of a trip and a visiting or recreational activity at the other end.

■ Home-based other trips

Home-based other trips include all other trips with a home activity at one end of a trip and an activity not already accounted for in one of the other home-based trip making categories described above at the other end.

■ Work-based other trips

Work-based other trips are non home-based trips where one end of a trip, either the origin or the destination, is from/to the work location. An example of such a trip would be, "running an errand during lunch hour" from one's place of employment.

■ Other-based other trips

Other-based other trips are all other trips that do not begin or end at a trip-maker's home or place of work.

Estimation of Trip Productions

Total daily trip productions in a zone are estimated separately for each of the trip types listed above, using a series of cross-classification models. These models use the number of households in each zone to produce daily trips. The cross-classification models apply trip rates (person trips per household) to the number of households in each zone and in each household category (for example, household with no vehicle, with one vehicle...and the number of persons in each household) by household income group. Submodels are used to subdivide the total number of households in a zone into the household subtotals.

Non-Work Trip Productions

Described below is the methodology used in the cross-classification of households for the following non-work trip types.

- ■ **Home-based elementary/high school trips**
- ■ **Home-based college/university trips**
- ■ **Home-based shopping trips**
- ■ **Home-based social-recreational trips**
- ■ **Home-based other trips**
- ■ **Other-based other trips**

Households are categorized according to **household size** (the number of persons residing in a household). An allocation is made of the total households in a TAZ for each of the following six "household size" categories: 1-person, 2-person, 3-person, 4-person, 5-person, and 6 or more person households.

Households are then cross-stratified by **auto ownership** (the number of automobiles owned at the household). An allocation is made of each household subtotal for each of the following five auto ownership levels: 0 autos owned, 1 auto owned, 2 autos owned, 3 autos owned, and 4 or more autos owned.

Trip rates by purpose are then applied to the cross-classification of households by "household size" and "auto ownership level" in each TAZ to estimate trip productions for the non-work trip types. The trip rates by purpose were developed using the Year 1990 Travel Survey.

Work Trip Productions

A separate, three-way cross-classification of households in each TAZ is used to estimate trip productions for the following work related trip types:

- ■ **Home-based work-direct trips**
- ■ **Home-based work- strategic trips**
- ■ **Work-based other trips**
- ■ **Home-based work-at-home trip productions**
  (work-at-home is reported for informational purposes and is not used in subsequent model steps)

The three-way cross-classification is based upon:

- • **Household size**
- • **Number of workers in the household**
- • **Household income group**

Household size is defined by the following categories:

- • **1 person per household**
- • **2 persons per household**
- • **3 persons per household**
- • **4 persons per household**
- • **5 persons per household**
- • **6 or more persons per household**

The **number of workers** in the household is as follows:

- • **0 workers in the household**
- • **1 worker in the household**
- • **2 workers in the household**
- • **3 or more workers in the household**

The **household income** group categories for households are as follows:

- **Low Income:** Household income less than $19,999

- **Medium Income:** Household income $20,000 to $49,999

- **High Income:** Household income $50,000 or greater

The income levels correspond to levels used in the mode choice model. For internal consistency with the model's key components, the income values are in 1989 dollars.

Trip rates by purpose are then applied to the cross-classification of workers in each TAZ to estimate trip productions for the work trip types.

Specifications for all trip production cross-classification models containing the trip rates by purpose and by household type used in the Year 2000 Model Validation are presented in Appendix D.

Estimation of Trip Attractions

Trip attractions are estimated by a set of equations that were calibrated (or adjusted) considering data from the Year 1990 SCAG Household Survey. The final trip attraction models are described in Appendix E.

Balancing of Trip Productions and Attractions

Trip production and trip attraction estimation procedures by trip type result in totals that do not match. Therefore, it is necessary to balance trip productions and trip attractions by trip type before trip distribution is undertaken. The following practices were employed to balance trip productions and trip attractions:

- **Home-based work** trip attractions were balanced to home-based work trip productions within each of the six home-based work trip production categories (direct vs. strategic, and low, middle, and high income household categories).

- **Home-based elementary-high school** trip productions and home-based college-university trip productions were balanced to the corresponding trip attractions in each of those two school trip categories.

- **Home-based shopping** trip attractions were balanced to home-based shopping trip productions.

- **Home-based social-recreational** trip attractions were balanced to home-based social-recreational trip productions.

- **Home-based other** trip attractions were balanced to home-based other trip productions.

Table 3-1

YEAR 2000 TRIP PRODUCTION SUMMARY BY TRIP PURPOSE AND BY COUNTY

TRIP PURPOSE CATEGORY	PERSON TRIP PRODUCTIONS					MODELING AREA TOTAL
	LOS ANGELES	ORANGE	RIVERSIDE	SAN BERNARDINO	VENTURA	
HB Work: Direct - Low Income	730,473	163,352	112,288	118,450	45,095	1,169,658
HB Work: Direct - Middle Income	1,820,746	540,730	298,262	331,432	136,357	3,127,527
HB Work: Direct - High Income	1,972,719	834,829	261,840	298,401	220,175	3,587,964
HB Work: Strategic - Low Income	101,266	21,638	15,142	15,618	5,599	159,263
HB Work: Strategic - Middle Income	270,814	80,768	48,385	55,621	20,769	476,357
HB Work: Strategic - High Income	284,964	123,998	41,290	47,898	33,028	531,178
Total HB Work: Direct & Strategic	*5,180,982*	*1,765,315*	*777,207*	*867,420*	*461,023*	*9,051,947*
HB Elementary - High School Trips	3,006,439	834,508	519,342	612,596	238,449	5,211,334
HB College/University Trips	1,023,442	305,989	159,036	186,337	81,631	1,756,435
HB Shopping Person Trips	2,840,417	996,499	462,993	488,173	261,285	5,049,367
HB Social-Recreational Person Trips	3,180,201	1,108,537	513,624	560,164	293,654	5,656,180
HB Other Purpose Person Trips	6,215,266	2,245,156	1,013,211	1,087,570	595,616	11,156,819
Work - Other Person Trips (NHB)	3,530,648	1,244,904	438,152	521,694	272,660	6,008,058
Other - Other Person Trips (NHB)	6,733,980	2,096,843	1,095,246	1,182,065	557,957	11,666,091
TOTAL PERSON TRIPS	31,711,375	10,597,751	4,978,811	5,506,019	2,762,275	55,556,231

Notes:
HB=Home-Based, NHB=non-Home-Based. Data shown are prior to adjustment to TDM and cordon trips.

Table 3-2

YEAR 2000 TRIP GENERATION COMPARATIVE STATISTICS						

(a) Home-Based Work Trips	County					MODELING AREA TOTAL
	LOS ANGELES	ORANGE	RIVERSIDE	SAN BERNARDINO	VENTURA	
TRIPS	5,180,982	1,765,315	777,207	867,420	461,023	9,051,947
TRIPS per DWELLING	1.65	1.88	1.54	1.66	1.89	1.69
TRIPS per VEHICLE	0.88	0.90	0.83	0.84	0.84	0.88
TRIPS per WORKER	1.27	1.28	1.26	1.28	1.28	1.27
% Home-Based Work TRIPS	16.3%	16.7%	15.6%	15.8%	16.7%	16.3%

(b) Total Trips	County					MODELING AREA TOTAL
	LOS ANGELES	ORANGE	RIVERSIDE	SAN BERNARDINO	VENTURA	
TRIPS	31,711,375	10,597,751	4,978,811	5,506,019	2,762,275	55,556,231
TRIPS per DWELLING	10.11	11.29	9.89	10.55	11.30	10.40
TOTAL VEHICLES OWNED	5,856,716	1,970,292	931,080	1,029,189	551,255	10,338,532
TRIPS per VEHICLE	5.41	5.38	5.35	5.35	5.01	5.37
TRIPS per CAPITA	3.37	3.76	3.32	3.33	3.71	3.45

- **Work-based other** trips in the modeling area were estimated by the trip production model. Work-based other trips are generated at the workers home zone. The actual location of the trip end is based on the "production-trip ends" and the "attraction trip ends" are balanced to the total work-based other trips estimated for the Region by the trip production model.

- **Other-based other** trips in the Region were estimated using the trip production model. The actual location of the trip ends is determined by the "attraction allocation" model. Other-based other trips are symmetrical; i.e., the number of out-bound trips is equal to the number of in-bound trips for any TAZ. Basically, production trips are equal to attraction trips.

Trip Generation Results and Findings

The Year 2000 trip generation model estimated that 55,556,231 person trips were generated on a typical week-day in the Region's modeling area. Table 3-1 identifies the person-trip summary of those trips broken down by county and by trip type. The previous summary total from the 1997 SCAG model was 54,864,900 person trips. Considering the 52,864866 total daily person trips in Year 2000, 9,051,947 or 16.3 percent, were home-based work trips.

Table 3-2 provides summary statistics for person trips, by county and for the Region. The Table identifies selected comparative statistics, such as trips per dwelling unit, trips per vehicle owned, and trips per capita (person). Table 3-2 also identifies statistics for home-work trips, and total trips. Trips per dwelling, trips per vehicle, and trips per capita within the Region were up slightly from 1997 Model Validation results. For example, trips per dwelling were estimated at 10.40 in Year 2000, up from an estimated 10.29 in 1997. Trips per vehicle were estimated at 5.37 in Year 2000, down from an estimated 5.42 in 1997. Trips per capita were estimated at 3.45 in Year 2000, up from an estimated 3.32 in 1997.